RED PINE AND THE EUROPEAN PINE SHOOT MOTH IN ONTARIO

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ABSTRACT

The European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller), is a pest of red pine (*Pinus resinosa* Ait.) and Scots pine (*Pinus sylvestris* L.) plantations in Ontario south and west of a line from Manitoulin Island to Brockville. The life history of the moth is outlined and types of damage done to the trees are described in this report. Several situations that have a strong influence on population levels and extent of damage are described, and management practices are recommended to take advantage of these situations. Site, climate and plantation age are factors to be considered before planting red pine. Control procedures include: 1) not planting red or Scots pine on the tops of hills; 2) pruning infested shoots and/or removing lower branches to eliminate favorable overwintering sites; 3) not mixing young with old red pine; 4) using recommended insecticides at appropriate times; 5) promoting parasites by encouraging the growth of certain beneficial flowering plants within and around plantations.

RÉSUMÉ

La Tordeuse européenne des pousses du Pin, *Rhyacionia buoliana* (Schiffermüller), est un fléau du Pin rouge (*Pinus resinosa* Ait.) et du Pin sylvestre (*Pinus sylvestris* L.) dans des plantations sises en Ontario, au sud et à l'ouest d'une ligne partant de l'Ile Manitoulin pour se terminer à Brockville. Le présent rapport souligne le cycle vital du papillon et les types de dégâts causés aux arbres. Plusieurs situations qui ont une grande influence sur les niveaux de population ainsi que l'étendue des dégâts y sont décrits et l'auteur recommande des pratiques d'aménagement ayant pour but de profiter de telles situations. La station, le climat et l'âge de la plantation sont des facteurs à retenir avant de planter du Pin rouge. Les moyens de répression comprennent entre autres: 1) ne pas planter de Pins rouges ou Pins sylvestres sur le haut des collines; 2) élaguer les pousses malades et/ou couper les branches basses pour éliminer les lieux d'hibernation favorables à l'insecte; 3) ne pas mélanger les vieux Pins rouges avec les jeunes; 4) utiliser les insecticides recommandés aux temps appropriés; 5) favoriser les parasites en faisant pousser certaines plantes à fleurs, qui seront salutaires au sein et aux alentours des plantations.

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INTRODUCTION

The European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller), has been a pest of red pine (*Pinus resinosa* Ait.) and Scots pine (*Pinus sylvestris* L.) plantations since its introduction into Canada prior to 1925 and it persists as a pest in Ontario south and west of a line from Manitoulin Island to Brockville. During the 1950s it was such a serious pest that the planting of red pine within this entire region was discouraged (Pointing and Green 1962). Severe winters in the 1960s depressed shoot moth populations through much of this region, especially in the northern portions, and currently the only extensive area of severe infestation is confined to Wellington, Waterloo, Brant and Wentworth counties. However, there are pockets of infestation throughout the entire region and these will serve as reservoirs for future infestations. Accordingly, future plantings of red pine in this region cannot be expected to remain free of shoot moth.

During our study of the European pine shoot moth, we have noted many cases in which alternative management practices would have lessened the damage to red pine planted in this area. It is the purpose of this report to set forth the principles and practices that will assist the private plantation owner and the professional forest manager in deciding when and where to plant red pine or Scots pine, if they are to be planted at all.

LIFE HISTORY AND DAMAGE DONE TO TREES

The European pine shoot moth is rusty brown, marked with irregular bands of silver, and when resting closely resembles a dried or damaged bud. Wing expanse is about 16-24 mm. The moths fly from early June to mid-July, for 2-4 weeks, depending on the weather. The females lay their flat, oval, 1-mm-long eggs on the new growth, usually on the stem or needle bases, and these hatch in about 10 days. Any branches may be selected for egg-laying, but branches below grass level are relatively immune from attack. The young larvae mine into the needle bases causing the needles to turn brown, but this apparently does no appreciable damage to the trees. Small, resin-encrusted silk webs are spun between mined needles and the stem, or between the needles and the buds at the tip of the shoot. After mining several needle pairs, the larvae move up to the buds and spin a larger web, lined with resin, between two buds or a bud and nearby needles. They then eat into the bud and destroy it. Several such buds may be destroyed before mid- to late August, when the larvae cease feeding for the winter. Although the larvae show no preference for the central bud of a cluster, if the terminal bud of the tree is destroyed at this time, several lateral buds will compete for dominance, and a double or multiple stem will grow from that point upwards (Fig. 1). At high shoot moth population levels, the entire top cluster of buds may be destroyed. In this case many adventitious or extra buds become active lower on the stem, resulting in a "witch's broom" (Fig. 2). Repeated killing of the top shoots results in the death of the stem top, or a "spike top" (Fig. 3).

Typical damage by European pine shoot moth

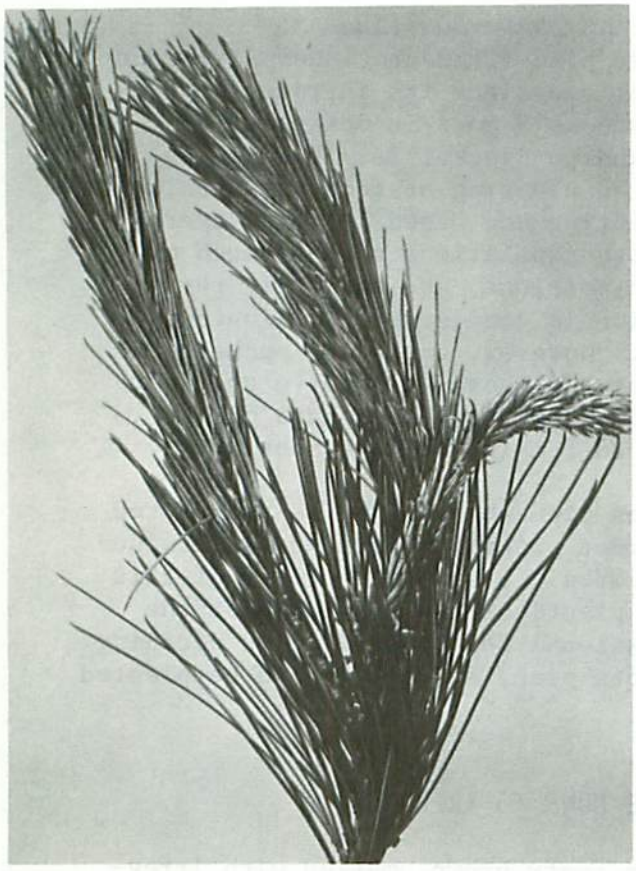

Fig. 1. (left) Destroyed central shoot resulting in double leaders.

Fig. 2. (below) Witch's broom resulting from destruction of all buds on leader.

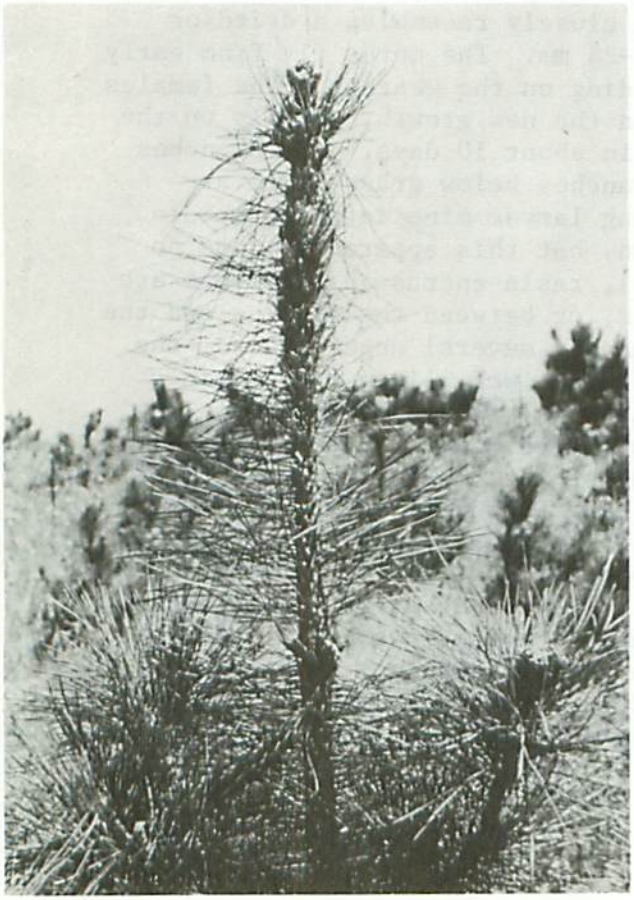

Fig. 3. (left) Spike top resulting from repeated killing of buds.

Typical damage by European pine shoot moth

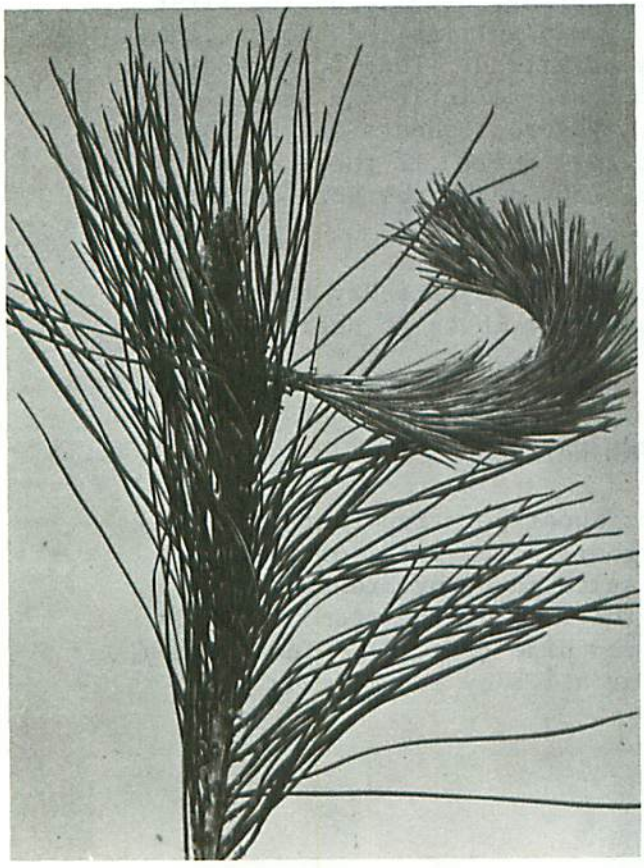

Fig. 4. (left) Damaged shoot showing early stage of posthorn development.

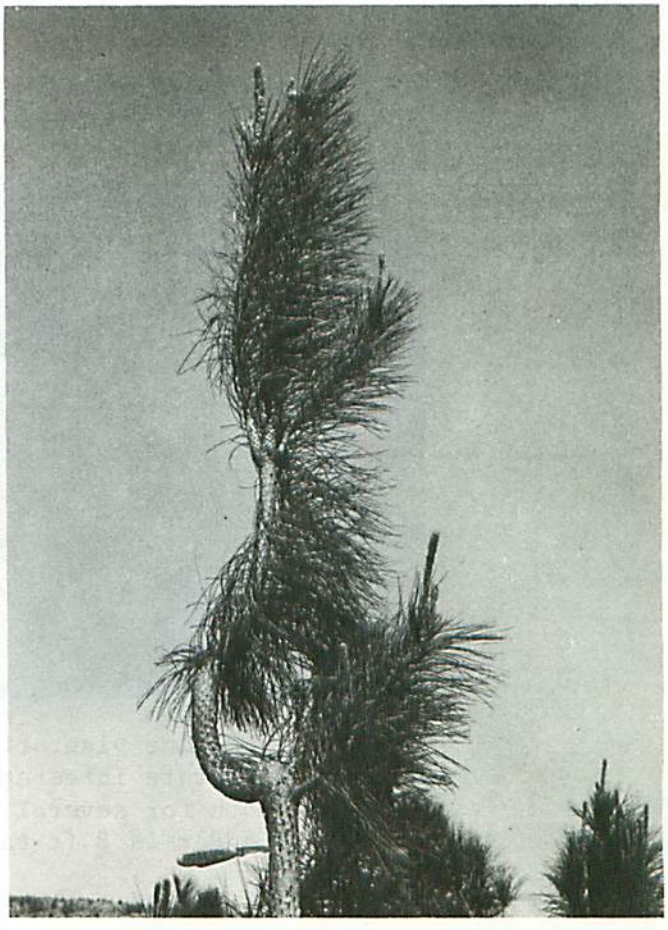

Fig. 5. (right) Posthorn or crook resulting from damage as shown in Figure 4.

Feeding is resumed in the early spring, usually by the first week of May, and more buds are killed by mining. As the shoots elongate and form "candles", these too may be killed. They turn reddish brown and usually bend over, causing a characteristic and easily seen symptom of shoot moth attack (Fig. 1). Vigorous shoots may not be killed by mining, but are weakened and fall over. If these do not break off, they resume vertical growth, causing a "posthorn" or crook (Fig. 4 and 5) in the tree.

The larvae pupate within the shoots from late May to mid-June and the next generation of moths emerges from these to begin the cycle again.

LEVELS OF DAMAGE AND HAZARDS

There is really only one bud or shoot per tree that is of concern to the grower of red pine and that is the lead, or terminal bud. The destruction of other buds results in bushy branches or reduced laterals, but does not impair the form of the stem, which is the economically important feature of red pine (Fig. 6). In addition, although red pine is normally planted at a 1.8 by 1.8 m (6 by 6 ft)

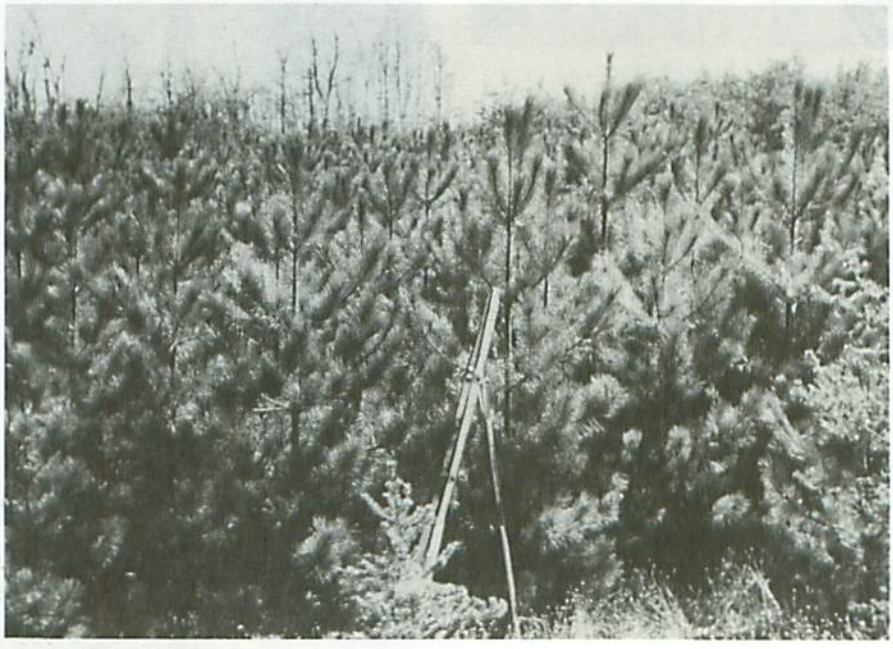

Fig. 6. Red pine plantation that has sustained a moderate infestation of European pine shoot moth for several years. Note straight stems. Ladder is 8 ft tall.

spacing, it is not normally harvested at this density. There are inevitably cull trees. Thus, the level of shoot moth population can be regarded as economically tolerable if the insect does not add appreciably to the number of cull trees. Moreover, moderately severe deformities, caused by early attack of shoot moth, are frequently overgrown by the time the tree is harvested (Fig. 7-9). We are concerned, therefore, with the question of whether red pine planted in any particular area will be heavily or lightly attacked by the European pine shoot moth. Although nothing can guarantee immunity from attack by the shoot moth within the area of its distribution, we can take advantage of certain climatic factors and behavioral characteristics.

Trees on hilltops

Frequently, red pine or Scots pine are planted on the drier sites at the top of hills. In the range of shoot moth, this is a mistake for two reasons. In the first place, the trees are on a drier site, and they suffer from lack of water much more frequently than do those on wetter sites. Shoot moth larvae establish and survive better on trees on drier sites than on trees in moister locations. Therefore, red pine at the tops of hills will be more susceptible to damage by the shoot moth than trees planted on lower sites.

Secondly, adult shoot moth females tend to fly upwind in a light breeze. Their normal flight and egg-laying period is at dusk. This time of day in midsummer is characterized by little wind so that the major wind factor in rolling country in the late evening is frequently the downhill drainage of cold air. Active female shoot moths fly against this cold air drainage and arrive at the tops of the hills where the most susceptible trees are located. Thus, through a combination of site and female behavioral characteristics, the greatest density of egg-laying female shoot moths occurs where the most susceptible trees are located, i.e., at the tops of hills.

Low winter temperatures

Shoot moths overwinter as half-grown larvae in the buds and are exposed to ambient air temperatures that may fluctuate widely. Mortality due to freezing during the winter months is an important factor in the population dynamics of the European pine shoot moth in southern Ontario (Green 1962). As winter temperatures decrease, mortality increases and virtually no larvae can survive air temperature of about -29°C (-20°F). If this temperature is reached once during a winter, all larvae exposed to it will die. This becomes a limiting factor in the north. The mean minimum temperature isotherm of -29°C (-20°F) corresponds very closely with the northern limit of continuous shoot moth distribution. The less the likelihood of having a minimum

Fig. 7. Red pine with severe posthorn and double stem (a) 1959 (b) 1965 (Note complete dominance of right hand stem.) (c) 1967 (d) 1975.

Fig. 8. Red pine with double posthorn (a) 1959 (b) 1967 (Note straightening and twisting of stem.) (c) 1969 (d) 1975 (Note complete overgrowth of deformity.)

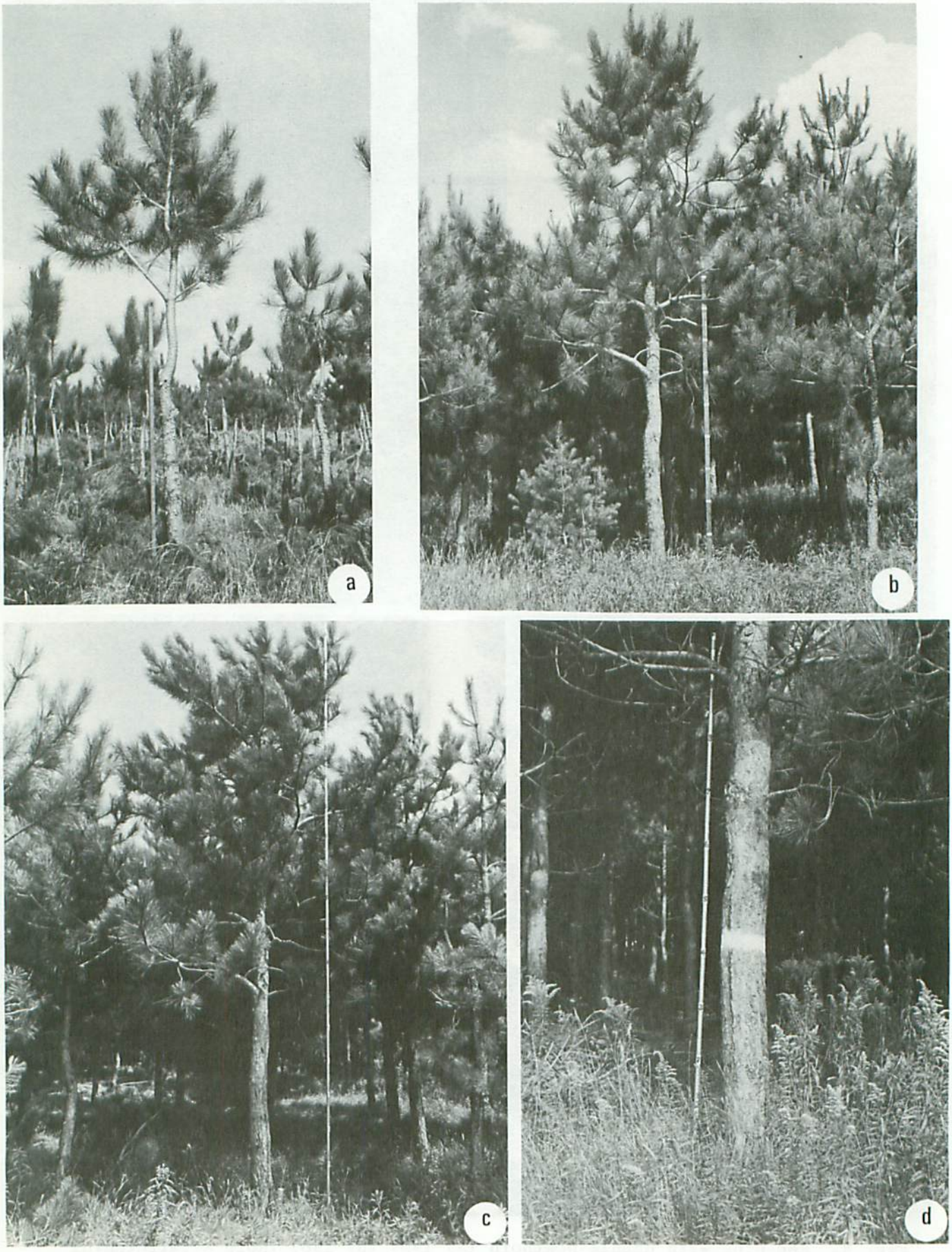

Fig. 9. Red pine pruned to eliminate double stem at 5.5 ft (a) 1959 (b) 1965 (c) 1967 (d) 1975 (Note quick recovery.)

temperature of -29°C (that is, the farther south one is), the greater the chances are of an initial population building up to a serious threat over the years.

However, even in northern latitudes air temperatures as low as -40°C (-40°F) do not affect larvae on branches close to the ground and protected by a foot of snow. Thus, fairly large trees with a small proportion of their branches near the ground, and even bigger trees (6 m and more), with no branches covered by ground snow in the winter, will be cleared of most or all of their shoot moth infestation by one night of -29°C temperature. In any winter, they will be cleared of a larger proportion of shoot moth than small trees protected by a heavy snowfall.

It is easy to see, then, that trees in the north where annual snowfall is light, e.g., north of Lake Ontario, will be better protected from infestation by the European pine shoot moth than trees in the south, experiencing mild winters, or trees in the north in areas where the annual snowfall is heavy, e.g., in the Georgian Bay area (Green 1962).

Plantations of mixed ages

Most of the red pine in county forests in southern Ontario is planted on very dry, sandy sites. It has been our experience in these plantations that the shoot moth populations begin a sharp decline when the trees reach a height of about 3.6 m (12 ft), and within about 3 years become extinct.

Various studies in Ontario and elsewhere (Esbjerg 1970) suggest that this is probably related to the availability of water and that when trees on these sites reach this height, their roots penetrate the water table and are no longer subject to annual stresses from lack of water in dry summers. They thus become more resinous and therefore more resistant to shoot moth attack.

Although larger trees are less susceptible to shoot moth damage, and generally do not sustain a population for many years, they are not immune; if attacked repeatedly from another source of infestation, they can be damaged considerably. Several cases have been noted where larger red pine, previously undamaged by shoot moth, were severely attacked at a high level above ground (Fig. 10). When this was backdated, it was found that the damage had occurred when new red pine, infested with shoot moth, were planted nearby. Another case involved trees 9 m (30 ft) tall repeatedly attacked by moths from smaller, severely infested, adjacent pines. Since plantation-grown red pine is suitable for poles (Anon. 1968), damage at this age and to this extent can cause a tremendous reduction in the potential value of such trees.

Fig. 10. Older red pine damaged at a later stage by a heavy attack of European pine shoot moth.

CONTROL MEASURES

Planting areas

Knowing that female shoot moths tend to congregate at the tops of hills where the most susceptible pines grow, we can take advantage of this phenomenon and yet another behavioral characteristic of shoot moth, *viz.*, females will lay eggs on other less susceptible pines and even on other coniferous species. Therefore, if other coniferous species are planted on hilltops, the shoot moths are attracted to that site and will lay eggs on them, in the absence of red pine or Scots pine. However, the majority of young larvae on these trees will not survive to produce adults, and so this part of the insect population is destroyed. They will survive for a time on most of the pines, but not as well as on red pine or Scots pine.

If red pine is a desired species, and the topography is rolling, planting should be restricted to the flanks of slopes or to valleys, depending on the moisture.

Cold winter temperatures and pruning

In areas where winter temperatures may fall to -29°C (-20°F), the private tree grower and forest manager can take advantage of the lethal effects of these extreme temperatures by pruning the lower branches of smaller trees to eliminate or at least decrease the proportion of the crown that will be under snow. This reduces the number of overwintering sites that are favorable for shoot moth and, during a severe winter, will help to reduce the surviving population. It is acknowledged that this is a time-consuming job and may not be economically feasible on a large scale, but on a small scale it would be worth considering. A bonus from this practice is an improvement in stem form by early removal of branches. One must be careful, however, not to remove too many branches or too great a proportion of the crown at a time. Removal of one third to not more than one half of the crown will not usually impair the growth of an otherwise vigorous tree.

If young trees are supporting a moderate to high infestation, trimming the outer third off the new growth, as is done by Christmas tree growers, in late July or early August, will eliminate much of the population. If care is taken not to trim the leader, a straight-stemmed but bushy tree will result. Again, however, this practice is laborious and time-consuming.

For individual, small ornamental trees, removing individual infested shoots in mid-May and destroying them will eliminate the potential moths for that year. Covering the sound shoots from late May to late June with pieces of cheesecloth will protect them from moths that may fly in from adjacent trees. This method, though time-consuming, is a sure way to protect a few valuable trees during the time they are most susceptible to severe damage by shoot moth, i.e., when they are less than 4 m high.

Mixed ages

We have shown that older, relatively immune trees can be severely damaged when attacked by a vigorous population of shoot moth breeding on young, susceptible trees nearby. It seems inadvisable, therefore, to plant young, susceptible red pine in an area where shoot moth exists on older trees because the moths will move from the older to the younger trees instead of dying out. On the younger trees, they will continue to multiply and then fly back into older trees and damage them. The problem would not arise if there were no shoot moth in the area, but planting young red pine near older ones would set up a potentially dangerous situation if the moths were later introduced.

Chemical control

Chemical control of the European pine shoot moth on a large scale is not satisfactory for ecological and economic reasons. The shoot moth larva spends most of its life within the tree (i.e., mining in the needles or buds), and even when moving from needle to needle or from bud to bud, it remains close to the bases of the needles and buds. A contact insecticide would have to drench the trees to reach the needle bases and buds, which are protected by a cone of needles, and this would reach only a small number of wandering larvae at any one time. Larvae within buds or needles would be protected. Stomach poisons would also have to be applied at a high rate to reach the buds, but even then the shoot moth larva does not consume the outer part of the bud (Pointing 1962) and so may avoid the effect of the poison by spitting the poisoned material out. With contact and stomach poisons, the high rate of application of the insecticide would create a danger to wildlife, including the natural predators and parasites that tend to suppress the shoot moth.

Systemic poisons, which are taken up by the plant, making the whole tree toxic, have been tried with varying success in Europe and North America. Generally, however, the cost of this type of insecticide is prohibitive for use on a large scale, and few are registered for this use because of their toxicity.

Recommendations for currently registered pesticides are given in publications 312 and 383 of the Ontario Ministry of Agriculture and Food (Anon. 1974, 1975). Remember to follow the instructions on the container for safety's sake. The timing of application of pesticides recommended for control of the European pine shoot moth is very critical. Failure of a recommended pesticide to control the shoot moth will usually be due to improper timing of application. The determination of the precise time, which is temperature-dependant, would require monitoring of shoot moth development in the field each year. The cost of pesticides and the labor to apply them rule out their use in most commercial situations. The cost and labor required to ensure the protection of a few high-value ornamental trees may be acceptable, but in these cases hand pruning of infested shoots will usually do the job.

The encouragement of parasites

The shoot moth has a fairly large number of parasites that attack its various stages. These are mainly wasps that lay their eggs in the shoot moth larvae or pupae. These eggs hatch and the wasp larvae live in or on the shoot moth, eventually killing it. As adult wasps, however, they must have a source of food for energy or for developing their eggs. This food source is typically nectar or pollen from flowering plants. For this reason, flowering plants should be

encouraged rather than eradicated within and around plantations. The species of flowering plants listed in Table 1 are of prime importance to the particular parasites that attack the shoot moth and are presented in descending order of importance (Syme 1975, 1976).

The presence of these flowers in pine plantations will not assure the biological control of shoot moth by its parasites, for the success of the parasites depends on too many other uncontrollable factors such as weather. However, if suitable food were present, the parasite would have a chance to perform at peak efficiency and even if other conditions were not optimal, the presence of food would allow a longer lifespan and thereby increase the chances for improved success.

It is therefore in the plantation manager's best interests to encourage the growth of a variety of flowering plants among his trees (within the bounds of local weed control legislation), especially those listed in Table 1. Of these, buckwheat (*Fagopyrum esculentum* Moench) and wild carrot (*Daucus carota* L.) are the preferred food of our most effective parasite (Syme 1976). They therefore have the most potential for promoting the success of the parasite and the destruction of the pest.

Buckwheat must be replanted each year in the regional municipality of Waterloo and in Wellington County. Seeding at the beginning of June followed by a second seeding 2 weeks later provides an extended bloom period for the parasite *Orgilus obscurator* Nees. Wild carrot is a biennial and will not compete with dense turf. Some form of soil disturbance is necessary to allow its establishment. If there is abundant wild carrot on nearby roadsides or fencerows, its seeds will likely be present in the plantation and will need only scarification or surface disturbance of the soil to germinate. If wild carrot is not present, then its seed is easily hand-collected by cutting off the seed-heads in the early fall. Two people with clippers can easily collect a bushel of seed-heads in an hour or less. These should be ground between the hands and the seed scattered on open soil in the spring. Because wild carrot is a biennial, it takes 2 years to bloom. Therefore, several areas within the plantation should be disturbed with a plough or disc-harrow and one third of these redisturbed each year. This will allow one third to remain undisturbed for 2 years and enable the wild carrot to come to bloom. Once wild carrot is established within the plantations, it will not require seeding by hand.

Alternatively, if a firebreak is maintained around the plantation, a modified ploughing or discing schedule will ensure an annual undisturbed area in which wild carrot can germinate, develop and bloom. This would require a firebreak two and one half times as wide as the minimum gang-plough or disc-harrow width. Figure 11 illustrates the scheme for cutting the firebreak in midsummer. Thus, in the first year one pass is made to turn the sod and expose the soil. This will allow

TABLE 1. List of flowering plants to be encouraged in red pine plantations for the control of the European pine shoot moth (arranged in descending order of importance).

Common name		Scientific name
Buckwheat		*Fagopyrum esculentum* Moench
Wild carrot	*	*Daucus carota* L.
Milkweed	*	*Asclepias syriaca* L.
Catnip		*Nepeta cataria* L.
Apple blossom		*Pyrus malus* L.
Alyssum		*Alyssum alyssoides* L.
Hound's tongue		*Cynoglossum officinale* L.
Red sorrel		*Rumex acetosella* L.
Motherwort		*Leonurus cardiaca* L.
Black medick		*Medicago lupulina* L.
Chickweed		*Stellaria media* (L.) Cyrill.
Narrow-leaved vetch		*Vicia angustifolia* Reichard
Goat's beard	*	*Tragopogon* sp.
Dandelion		*Taraxacum officinale* Weber
Climbing nightshade		*Solanum dulcamara* L.
White clover		*Trifolium repens* L.
White sweet clover		*Melilotus alba* Desr.
Alfalfa		*Medicago sativa* L.
Common burdock	*	*Arctium minus* Schk.
Bull thistle	*	*Cirsium vulgare* (Savi) Tenore
Great willow-herb		*Epilobium angustifolium* L.
Star thistle		*Centaurea maculosa* Lam.
Ox-eye daisy		*Chrysanthemum leucanthemum* L.
Bladder campion	*	*Silene cucubalus* Wibel
Ground cherry		*Physalis heterophylla* Nees
Strawberry		*Fragaria vesca* L.
Yellow sweet clover		*Melilotus officinalis* (L.) Desr.
Soapwort		*Saponaria officinalis* L.
Red clover		*Trifolium pratense* L.
Blue-weed		*Echium vulgare* L.
Bindweed	*	*Convolvulus arvensis* L.
Common St. John's-wort	*	*Hypericum perforatum* L.
Yarrow		*Achillea millefolium* L.

*These species are designated noxious weeds in some parts of Ontario (Anon. 1966).

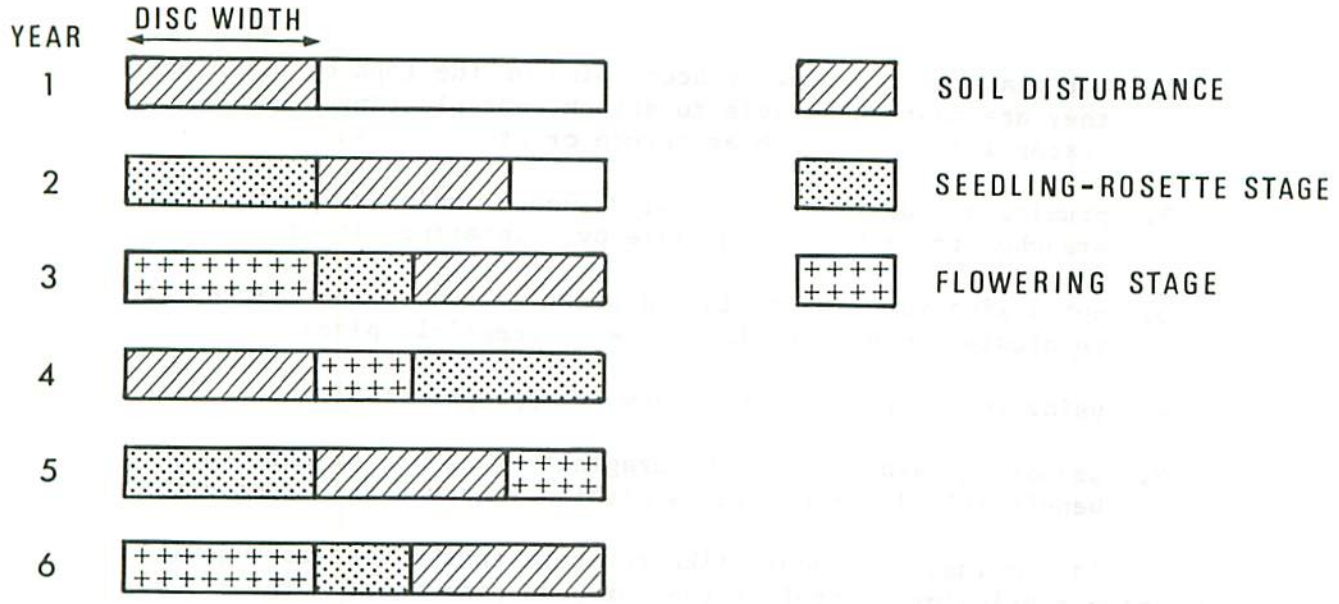

Fig. 11. Scheme for discing a firebreak to allow wild carrot to bloom in it each year.

seeds to settle in the fall and following spring. They will germinate in the second year, forming the rosette stage of the carrot. Meanwhile, the second cut is made next to the first, exposing the soil for seeds in the fall. In the third summer, the first swath has mature wild carrot plants that will bloom in the late summer. The third cut is made, overlapping the second to conserve space if necessary. This allows a half width to germinate and form the rosette stage. In the fourth summer, the first swath which bloomed the previous summer is recut, the half swath in the middle blooms that year, and the right-hand swath is in the rosette stage. By moving the plough/disc over each year, one can ensure that there is always a strip of blooming wild carrot.

SUMMARY AND CONCLUSIONS

In the dry, sandy soils on which red pine is often planted in southern Ontario, the species is frequently under moisture stress and is therefore susceptible to the attacks of the European pine shoot moth. To lessen the potential for damage by this pest, the forest manager can follow certain practices that either take advantage of the moth's behavior or increase the effectiveness of natural control agents such as parasites. These include:

1. not planting red pine or Scots pine on the tops of hills where they are most vulnerable to attack, but planting other less susceptible trees such as spruce or other pines;

2. pruning and destroying infested shoots and/or removing lower branches to eliminate suitable overwintering sites;

3. not mixing young with old red pine, to lessen the chances of reinfestation of the older, less susceptible pine;

4. using recommended insecticides at appropriate times;

5. promoting parasites by encouraging the growth of certain beneficial flowering plants within or around the plantation.

In conclusion, I would like to state that no one method will guarantee continuing control of the European pine shoot moth, but by following any of these suggested procedures, one can increase the odds against serious economic damage.

REFERENCES

Anon. 1966. Weed control act. Government of Ontario. *In* Revised Statutes of Ontario, 1960, Chapter 427, as amended by Statutes of Ontario, 1965, Chapter 141, and Statutes of Ontario, 1966, Chapter 160, and Regulation 565, Revised Regulations of Ontario, 1960, as amended by Ontario Regulations 170/63, 112/64, 288/64, 61/65 and 185/65.

Anon. 1968. Plantation-grown red pine for poles. Res. News. Dep. For. Rur. Dev. May-June.

Anon. 1974. 1975-76 production recommendations for ornamentals and turf. Ont. Min. Agric. Food. Publ. 383. 40 p.

Anon. 1975. Pest control chart for ornamentals in the home garden. Ont. Min. Agric. Food. Publ. 312.

Esbjerg, P. 1970. Mortality of first instar larvae of the European pine shoot moth (*Rhyacionia buoliana* Schiff.) on waterlacking needles of lodgepole pine (*Pinus contorta* Loud.). Ent. Scand. 1:215-218.

Green, G.W. 1962. Low winter temperatures and the European pine shoot moth, *Rhyacionia buoliana* (Schiff.) in Ontario. Can. Ent. 94:314-336.

Pointing, P.J. 1962. The effectiveness of a microbial insecticide against larvae of the European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller). J. Insect. Pathol. 4:484-497.

Pointing, P.J. and G.W. Green. 1962. A review of the history and biology of the European pine shoot moth, *Rhyacionia buoliana* (Schiff.) (Lepidoptera: Olethreutidae) in Ontario. Proc. ent. Soc. Ont. 92 (1961):58-69.

Syme, P.D. 1975. The effects of flowers on the longevity and fecundity of two native parasites of the European pine shoot moth in Ontario. Environ. Ent. 4:337-346.

Syme, P.D. 1976. The effects of certain foods on the longevity and fecundity of *Orgilus obscurator* (Hymenoptera: Braconidae). Can. Ent. In press.